Satellite Irrigation Management Support with the Terrestrial Observation and Prediction System

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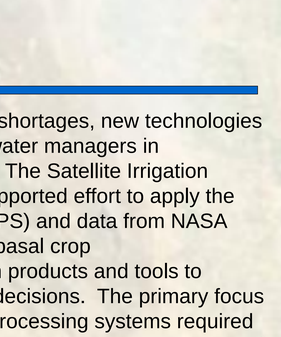
Abstract

In California and other regions vulnerable to water shortages, new technologies are needed to support agricultural producers and water managers in maximizing the benefit of available water supplies. The Satellite Irrigation Management Support (SIMS) project is a NASA supported effort to apply the Terrestrial Observation and Prediction System (TOPS) and data from NASA satellites to map basal crop coefficients (Kcb) and basal crop evapotranspiration (ETcb), and develop information products and tools to support agricultural producers in making irrigation decisions. The primary focus of the effort is to develop the computing and data processing systems required to support the use of satellite and weather data to provide rapid assessments of current crop conditions over large areas, and translate the data into formats that are useful to agricultural producers in irrigation scheduling and water management practices. The project is also building prototypes of web and mobile phone based reporting and data access systems to allow evaluation of data products by agricultural producers. To facilitate quantitative evaluation of the crop coefficient and ETcb maps produced, the project is working with California growers to deploy wireless sensor networks at sites throughout the San Joaquin Valley to collect information on soil moisture conditions and irrigation applications. In addition, surface renewal instrumentation is being deployed in collaboration with the California Department of Water Resources (CDWR). TOPS-SIMS is a component of the Water Management in California project, a joint effort by NASA Ames, NASA Marshall Space Flight Center, and the Jet Propulsion Lab to apply NASA capabilities to support improved water resource management in California,.

Approach

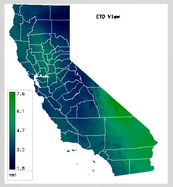
SIMS uses the TOPS modular architecture and is designed to support multiple approaches to estimating ET from satellite observations, including crop coefficient and energy balance approaches. System requirements developed with grower input included delivery of data with **minimal time lag and high spatial and temporal resolution**, therefore the initial implementation follows the FAO-56 approach, and builds upon past work by USDA ARS, CDWR, NASA and CSUMB. It utilizes data from the California Irrigation Management Information System (CIMIS), operated by CDWR, and methods developed by USDA ARS and partners that allow for use of data from a constellation of satellites to map crop coefficients and estimate ETc at high temporal and spatial resolutions. The project is utilizing the NASA Earth Exchange (NEX)[1] to process the complete Landsat archive for California from 2003 to present.



TOPS-SIMS Overview

Mapping Reference Evapotranspiration

CIMIS currently provides daily estimates of reference ET (ET_0) on a 2km statewide grid[2]. ET_0 is available for other western states through networks such as AgriMet and AZMET. In addition, NOAA NWS is currently developing ET_0 forecasts through the FRET project[3]. However, prescriptive tables frequently used to estimate Kc values for conversion of ET_0 to ETc do not readily account for site specific conditions or year to year variations in growing conditions, and so can differ from actual crop conditions.

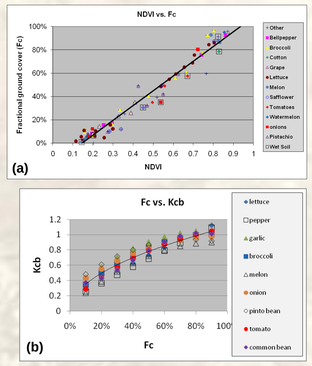


Daily CIMIS ET_0 for March 30, 2011

Approach (cont'd.)

Mapping Crop Coefficients

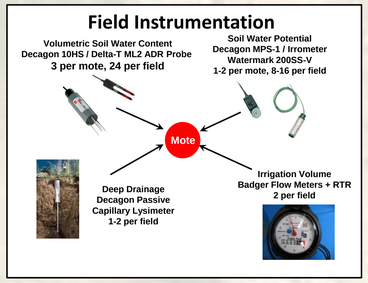
Recent research conducted by USDA ARS and partners has demonstrated that direct relationships exist between satellite indices of vegetation conditions, fractional canopy cover in crops, and crop coefficients for multiple crops[4,5]. Research to date has found these relationships to be robust across multiple crop types and canopy architectures, and because they rely on satellite indices that can be obtained from multiple satellite instruments, they allow mapping of crop coefficients to be conducted on a daily to weekly time step at a spatial resolution of 30-60m.



Relationships between NDVI and Fc (a), and Fc and Kcb (b) for multiple crop types.

Sensor Networks

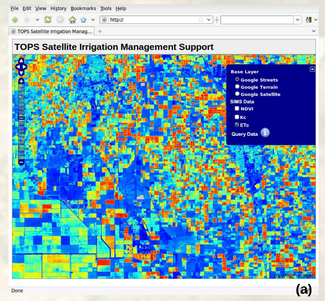
In cooperation with California growers, the project is currently deploying soil moisture monitoring networks in 15 fields throughout the San Joaquin Valley. Instrumentation is deployed at eight points within each field and provides measures of volumetric water content, soil water potential, deep drainage, irrigation volume, and meteorological conditions. In addition, in collaboration with CDWR and CSU Fresno, surface renewal stations[6] are currently being deployed at 10 of the 15 sites to provide an independent estimate of ET.



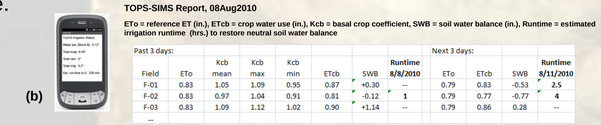
Instrumentation used in the wireless sensor networks deployed in each of the fifteen demonstration fields.

Data Distribution & Grower Interaction

Maps of NDVI, Kcb values, and estimated ETcb for the San Joaquin Valley will be distributed via a browser interface beginning in the Spring of 2011. The interface will allow growers to query the maps and extract time series of NDVI, Kcb, and ETcb values for regions of interest for use in evaluation for irrigation scheduling. In addition, the project is developing a reporting tool which will provide customized reports for individual fields that account for site specific conditions. The summary reports will also be accessible via a web browser or mobile phone.



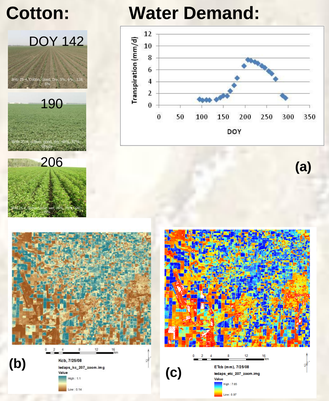
The TOPS-SIMS web browser interface (a), and a sample summary report (b).



Initial Results

Kc & ETc Mapping

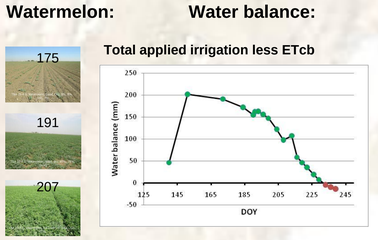
Kcb and ETcb maps are currently being produced and prepared for release via a web interface. Seasonal profiles for individual fields are also being prepared for evaluation by growers, and for comparison against previously collected surface renewal and eddy covariance data. In addition, Kcb based estimates of ETcb are being compared against energy balance derived estimates prepared for the 2010 growing season using SEBAL[7].



Sample seasonal ETcb profile for cotton (a); sample Kcb map (b); and a sample ETcb map (c).

Water Balance Modeling

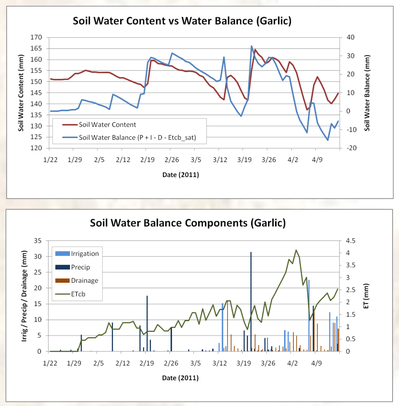
Retrospective comparisons of ETcb estimates against data on applied irrigation provided by growers are also being conducted at multiple sites for 2008-2010 to assist growers in evaluating data and identifying periods of over-irrigation and deficit irrigation. Sample results are shown for watermelons.



Seasonal water balance for a watermelon crop, showing positive water balance throughout much of the growing season, but deficit irrigation late in the growing season.

Satellite vs Surface Obs.

Surface renewal instrumentation will be used to provide ground validation of satellite estimates. In addition, relative changes in soil water content and soil water potential can be used to evaluate differences between estimated ETcb values and applied irrigation. Sample results are shown for a garlic crop.



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